

What is claimed is:

- 1 1. A semiconductor device, comprising a substrate having a substrate surface, a barrier film on the substrate surface, and a single crystal transition metal on the barrier film.
- 1 2. A semiconductor device according to claim 1, wherein the barrier film has a thickness less than approximately 250Å.
- 1 3. A semiconductor device according to claim 1, wherein the barrier film has a thickness less than approximately 100Å.
- 1 4. A semiconductor device according to claim 1, wherein the barrier film has a thickness in the range of approximately 20 to approximately 75Å.
- 1 5. A semiconductor device according to claim 1, wherein the metal comprises an elemental transition metal.
- 1 6. A semiconductor device according to claim 1, wherein the transition metal is selected from the group consisting of copper, silver, gold and platinum.
- 1 7. A semiconductor device according to claim 1, wherein the transition metal comprises copper.

1 8. A semiconductor device according to claim 1, wherein the barrier film comprises a
2 heteroepitaxial film structure comprising a monolayer of metal atoms selected from barium atoms,
3 strontium atoms, and cesium atoms, singly or in combinations thereof, located on said surface of
4 said substrate, and a homoepitaxial portion comprised a metal halide selected from barium halide,
5 strontium halide and cesium halide located between the monolayer and the metal.

1 9. A semiconductor device according to claim 1, wherein the substrate is selected from the
2 group consisting of single crystal silicon, polycrystalline silicon, SOI, SOS, gallium arsenide,
3 silicon carbide, indium phosphide, gallium nitride, aluminum nitride, germanium, indium
4 antimonide, lead telluride, cadmium telluride, mercury-cadmium telluride, lead selenide, lead
5 sulfide, and tertiary and quaternary combinations of these materials.

1 10. A semiconductor device according to claim 1, wherein the substrate comprises single
2 crystal silicon.

1 11. A semiconductor device according to claim 1, wherein the substrate comprises single
2 crystal gallium arsenide.

1 12. A semiconductor device comprising a single crystal substrate having a substrate surface, a
2 barrier film on the substrate surface, where said barrier film comprises homoepitaxial metal halide
3 and said barrier film having a thickness less than approximately 100Å, and single crystal metal
4 directly on the metal halide.

1 13. A semiconductor device according to claim 12, wherein the substrate is selected from the
2 group consisting of silicon and silicon oxide, the metal halide is selected from the group consisting
3 of barium halide and strontium halide, and said metal is selected from the group consisting of
4 copper, gold, silver, and platinum.

1 14. A process for making a semiconductor device comprising the steps of:
2 forming, on a surface of a substrate material, a barrier film; and
3 forming a single crystal transition metal on the barrier film.

Sub C 1 15. A process for making a semiconductor device according to claim 14, wherein the forming
2 of the barrier film comprises the following substeps:

3 vapor depositing a metal halide on the cleaned heated substrate surface at a temperature of
4 500 to 700°C, in a vacuum having a background pressure of less than approximately 10^{-11} Torr,
5 and wherein the metal halide deposition is conducted at a rate permitting the metal halide vapor to
6 react with the substrate surface to form a monolayer of metal atoms selected from barium atoms,
7 strontium atoms, and cesium atoms, singly or in combinations thereof, on said surface of said
8 substrate; and

9 continuing, after forming the monolayer, the vapor depositing of the metal halide to form a
10 metal halide layer regime upon the monolayer until the desired barrier film thickness has been
11 achieved.

1 16. A process for making a semiconductor device according to claim 14, wherein the forming
2 of the single crystal transition metal on the barrier film comprises depositing a transition metal on
3 the barrier film concurrent with heating the substrate and barrier film surface to a temperature
4 effective to cause the transition metal to assume a monocrystalline structure.

1 17. A process for making a semiconductor device according to claim 14, wherein the forming
2 of the single crystal transition metal on the barrier film comprises the substeps of depositing a
3 transition metal on the barrier film at a temperature below which the metal forms with a single
4 crystal structure, and then annealing the resulting metallized substrate at a temperature effective to
5 cause the transition metal to assume a monocrystalline structure.

1 18. A process for making a semiconductor device according to claim 14, wherein the forming
2 of the single crystal transition metal on the barrier film comprises depositing a transition metal on
3 the barrier film concurrent with heating the substrate and barrier film surface to approximately
4 375°C or higher.

1 13 19. A process for making a semiconductor device according to claim 18, wherein the transition
2 metal comprises copper. 12

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1 20. A process for making a semiconductor device according to claim 14, wherein the forming
2 of the single crystal transition metal on the barrier film comprises the substeps of depositing a
3 transition metal on the barrier film at a temperature below 375°C, and then annealing the resulting
4 metallized substrate at a temperature of 375°C or higher.

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15, 21.* A process for making a semiconductor device according to claim 20, wherein the transition
2 metal comprises copper.

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1 22. A process for making a semiconductor device according to claim 14, wherein the
2 barrier film comprises a homoepitaxial portion comprised a metal halide selected from barium
3 halide, strontium halide, and cesium halide, located between the monolayer and the transition
4 metal.

1 23. A process for making a semiconductor device according to claim 14, wherein the
2 homoepitaxial portion of the barrier film is selected from BaF₂, BaCl₂, SrF₂, SrCl₂, CsF, or CsCl.

1 24. A process for making a semiconductor device according to claim 14, wherein the barrier
2 film has a thickness of less than 100Å.

1 25. A process for making a semiconductor device according to claim 14, wherein the barrier
2 film has a thickness ranging from approximately from 20Å to approximately 75Å.

1 26. A process for making a semiconductor device according to claim 14, wherein the transition
2 metal is selected from the group consisting of copper, silver, gold and platinum.

1 27. A process for making a semiconductor device according to claim 14, wherein the transition
2 metal comprises copper.

1 28. A process for making a semiconductor device according to claim 14, wherein the substrate
2 material comprises a semiconductor.

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